551.55 : 551.3.053 SECTION II.—GENERAL METEOROLOGY.

COMPETENCY OF WIND IN LAND DEPLETION.

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The goal of all geological forces of land sculpturing is the perfect planation of all those parts of the lithosphere that project above the surface of the oceans. Of the three titanic powers of erosion ever at work leveling and lowering the face of the earth the wind receives least and last attention. Yet, as an agent of general denudation, the wind is actually not only more vigorous than any of the others but it is perhaps on the whole more competent than all others combined.

In the first half of the nineteenth century scientists considered the sea to be all-powerful in leveling off the lands. From his home in the British Isles Andrew Crombie Ramsay (*b.* 1814) could look out over the never-still waters and see all around him the ocean ceaselessly gnawing into the coasts and forming just beneath the water surface a broad smooth rock shelf. In fancy he could discern in the even sky-lines of his island former rock shelves that had long since been elevated above the reach of the waves. Projecting his virile mind into the future he could reckon the time when all England would be again planed off to sealevel and covered by universal waters. As a result of his musings there burst forth his great "planation theory of marine denudation."

When a generation later our own J. W. Powell (*b.* 1834), advancing a "theory of a base-level of erosion," gave expression to one of the half dozen great and brilliant geologic concepts of his century, the wearing down of the lands to sea surface was pictured as being accomplished alone by the corrading action of rivers. With the development of a definite erosion cycle through which all land forms must pass until they finally fade away to an even plain lying but slightly above tide-level, stream corrasion was extended to every land of Earth. All other agents of general land leveling and lowering were rigorously excluded.

Peneplanation is, then, a stern reality. It takes place whether or not running waters are present. Amidst waterless wastes general leveling and lowering of the lands plainly continues to go on as vigorously as in pluvial regions, but without appreciable aid from streams. That in countries of excessive dryness there should be recognized an erosive power more constant than the washings of the rains, more extensive and persistent than the encroachments of the sea is one of the recent novelties in geological science. Such power is eolian. Both as a sculpturing tool and as a sedimentative agent the wind is thus in every way the counterpart of river and ocean.

The idea of the competency of the wind to perform great regional erosion, work formerly believed to be only possible for stream and sea, is yet too new confidently to ascribe its origin to any one mind. Fifty years hence we may be better able to get proper perspective. Sure it is, however, that the specific fitting of wind work to geographic cycle is distinctly an American achievement. Whether first definitely outlined by a New World traveler on the Girghiz steppes, by a German on the South African veldt, or by a Yankee on the Mexican tableland, it is certain that, as McGee has astutely observed, the satisfactory disposal of the rock-waste of the desert by prodigious wind exportation supplies the missing link to a rational explanation of all those long puzzling phenomena presented by arid regions throughout the world.

The potency of the wind as a geologic agent appears to be a function of humidity, and of plant growth which binds the soil. The erosional work performed is in inverse ratio to the rainfall. When the annual precipitation is reduced to 10 inches or less vegetation becomes scant and bunchy, true aridity begins to prevail, and the winds are given full opportunity to transport and deflate the dry loose soil materials. Desert conditions obtain, according to Murray, over not less than one-fifth of the entire land surface of the globe. Over another one-fifth of the lands eolian action is more or less pronounced. Still another one-fifth is, or was within very recent geological times, covered by snow fields and, speaking physiographically, is to be regarded as truly desert as the Sahara. So that one-half of the land surface of our earth is subject to a greater or less extent to degradation by winds. To some indeterminate extent wind work is also prevalent over the remaining half of the lands. That it is not a more widely recognized circumstance is due mainly to the fact that it is the humid lands with which we are most familiar; and in pluvial countries it is customary, albeit erroneously so, to regard the rains as the sole graving tool in land sculpturing.

In order to quantitatively measure the grander work of the wind as a geologic process, to compare its relative efficiency with that of other erosional agencies, and to view it when it is most energetically active, we must turn from our moist climate homes to regions of excessive dryness. Yet all arid lands and deserts do not display the differential effects of eolic erosion equally well. The substructure of a dry region is a prime factor in the relief expression. In a tract like the dry South African plateau where the rocks are homogeneous and unfolded the contrasted relief effects of the wind are not so very marked. On the other hand in a region of close patterned orogeny, such as the Great Basin of the western United States, the plains of the Southwest, and the Mexican tableland, the larger effects of the wind in re-forming the facial expression of the earth are most striking and wind work is seen at its best.

The relative efficiency of wind as a geologic agency of erosion is most readily measured by comparing its transportative powers. These are most often seen in the "dust storms" which are the most familiar and frequent of desert phenomena. But their geological effects are seldom considered because of the fact that they cause such utter discomfort to the traveler that he can think of little else than of devising means of mitigating the evil effects. Almost every brisk breeze in the desert stirs up a dust cloud. This may soon become so dense as almost to shut out the light of the sun. The books on desert travels are full of these accounts and the experiences have been vividly depicted ever since the dawn of history.

In the bottom of the air-stream flow along the coarse sands and fine gravels, almost solidly it seems, for a height of a foot or two from the ground. Above this basal stratum are the fine sands which usually reach to the height of a man. Higher is the dark dense dust cloud reaching up into the thin atmosphere for a distance of a mile or more. Viewed from the tops of mountains that have greater elevation the dense dust cloud lies like a thundercloud all around as sharply distinguished from the clear upper air as is a sheet of water. Unlike the lazy mist cloud all is rapid motion. The dust-ladened stream is rushing along as some vast mountain torrent.

The "dust storm" or "sand storm" is in reality as much a transportative agent as any river. Matched with a large river it is a titan among flowing, sediment-ladened currents. Its width is 200 to 300 miles instead of only one as in the case of the largest watercourses. It sweeps along at a pace of 40 miles an hour instead of barely three or four miles. It carries along a hundred thousand times more sedimentative materials, the great bulk of which is soon borne entirely out of the arid country into the semiarid and humid lands far beyond. The tremendous volume of this deflated rock waste is amply attested by the enormous loess formations, the broad expanses of black soils of the steppes and prairies, and the extensive beds of plains marls which are displayed in so many parts of the world, especially on the lee sides of deserts. Epeirotic deposits [1] of this origin are only beginning to receive the attention that they merit.

Owing to the fact that the wind sweeps up its chips as fast as it cuts them the magnitude of eolic erosion is at first difficult to measure with any great degree of accuracy. Except under specially favorable conditions definite figures can not always be given. Only when a desert chances to have somewhere on its boundaries remnants of old peneplains highly uplifted, may the extent of regional depletion be closely estimated. As do moist lands under the influences of stream activities, so arid regions soon develop strong contrasts of surface relief under wind action. The belts of weak rocks are first profoundly worn down, leaving the hard rockmasses protruding as mountains. In a region of uniform flat-lying strata the relief contrasts are not always conspicuous. When, however, there are rock-beds of great thickness, alternating hard and soft members, with close patterned mountain structures as in the arid lands of the western United States, differential relief effects attain maximum extremes. In this tract it is that the extreme youthfulness of the lofty desert mountains is at once impressed with amazing vividness upon the mind of the observer fresh from his pluvial homeland.

When once plainly discriminated, wind-graved relief expression is seldom mistaken for any other kind. Its individuality is very strong. Wind-beveled surfaces are smoother than water-formed plains possibly can be. The rock-floors which characterize so many desert plains are phenomena as novel as they are unexpected. Desert ranges rising abruptly out of the plains about impart characteristic form to the enisled landscape. The girdled mountain attests the vigor of natural sand-blast action, and its maximum effectiveness at the plain line. Plateau plains of the desert manifestly represent former levels of the general plains surface. The notable absence of foothills around the mountain ranges appears to be an idiosyncrasy of arid lands. The planation process takes place uphill as well as down; antigravitational gradation is unknown where streams erode. The high gradients of the intermont plains and the strong pitch of the valley axes which are displayed on every hand are not possible in regions where water action is directly the reverse of plains-forming. Of minor features attributable to wind abrasion in the lands of little rain, there are a multitude that have been ascribed to normal water corrasion but that are now known never to have been touched by stream. Upon all these the wind marks, when once pointed out are unmistakable.

It so happens that the great arid tract of western America has near its borders abundant traces of a former baselevel plain [peneplain] now raised more than 2 miles above sealevel. The attainment of its present position is regarded as having taken place in late Tertiary times. It no doubt once extended over all this desert region, at a level somewhat above the tops of most of the present mountains. Since desert conditions began to set in about the same time there is every reason to believe that the magnitude of the erosion is represented by the difference between this old peneplain level and the present plains level—an interval of 5,000 or 6,000 feet—or something over 1 mile of thickness over an area equal to almost one-quarter of the entire United States. There are many considerations supporting the assumption that this area before uplift was a vast plain and not a mountainous district when arid climate was inaugurated. The inappreciable aid of stream corrasion in this prodigious regional depletion is supported by the very fact of the prevalence of aridity. This region is one of the best extant demonstrating beyond peradventure the almost boundless potency of the wind as an epicene power in re-forming the face of the earth.

Thus under favorable climatic conditions of aridity such as prevail to-day over nearly one-half of the entire land surface of our globe wind-scour is the chief agency of provincial leveling and lowering far more rapid and efficacious than any general erosion work by rain or ocean.

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REDUCTION OF AIR TEMPERATURES AT SWEDISH STATIONS TO A TRUE MEAN.[1]

By Nils Ekholm.

How far the material presented in this paper applies to American conditions is questionable. The experience of the Signal Service indicated that it was impracticable to require more than maximum and minimum temperature readings from its cooperative observers if satisfactory records were to be obtained in large numbers. In practice it has appeared that the mean temperatures from ½(max.+min.) form satisfactory planes of reference for comparison between different places and between different times at the same place, although the values thus obtained are almost always considerably higher than the means of the hourly observations. Charts and tables showing the corrections to be applied to means from different combinations of observation hours that have been used in the United States were published by Prof. F. H. Bigelow in United States Weather Bureau Bulletin S (Washington, 1909).

The accompanying abstract of Ekholm's paper is here presented in order to show the kind of study carried on in other countries; and also to emphasize the known fact that the mean temperatures universally employed in this country are convenient reference points rather than strictly true means.

The formulæ quoted are, for convenience, numbered consecutively in parentheses ( ); the designations used in Ekholm's original paper appear in brackets [ ].—*W. G. Reed.*

To obtain the true mean air temperature during any space of time hourly readings or better continuous autographic records are necessary. In the absence of

[1] Deposits originating within and stopping within the boundaries of the dry lands.—C. A., jr.

[1] Beräkning av luftens månadsmedeltemperatur vid de svenska meteorologiska stationerna. (Calcul de la température moyenne de l'air aux stations météorologiques *suédoises.) Bihang till meteorologiska iakttagelser i Sverige, bd. 56, 1914.* (Appendice aux observations météorologiques suédoises, vol. 56, 1914. [Swedish and French.] Stockholm, 1916. 111 p. f° *Abstracted* for the Review.